AD-A204 916)CUMENTATION PAGE

②

1a. REPORT SECURITY CLASSIFICATION	1b. RESTRICTIVE MARKINGS
UNCLASSIFIED	DTIC FILE COPY

2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT
	Approved for Public Release
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	Distribution is Unlimited

4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S)
	AFOSR·TR· 89-0114

6a. NAME OF PERFORMING ORGANIZATION	6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION
Yale University		AFOSR /NA

6c. ADDRESS (City, State and ZIP Code)	7b. ADDRESS (City, State and ZIP Code)
Dept. of Computer Science 51 Prospect Street New Haven, CT 06520	Dr. Ken Sakell AFOSR/NA Bolling AFB, DC 20332-6448

8a. NAME OF FUNDING/SPONSORING ORGANIZATION	8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
AFOSR	NA	AFOSR 86-0098

8c. ADDRESS (City, State and ZIP Code)	10. SOURCE OF FUNDING NOS.			
Dr. Ken Sakell AFOSR/NA Bolling AFB, DC 20332-6448	PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT NO.
	61102F	2307	A1	

11. TITLE (Include Security Classification) CFD RESEARCH FOR MINI-SUPERCOMPUTERS A YALE/UTRC PROGRAM

12. PERSONAL AUTHOR(S)
Gropp, William; Schultz, Martin

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Yr., Mo., Day)	15. PAGE COUNT
Final Report	FROM 2/15/87 TO 10/14/88	1/9/89	2

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB. GR.	Parallel processing, Algorithms, Domain Decomposition (···)
	20,04		

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Research is directed at the application of modern computer technologies, with emphasis on emerging parallel computing techniques to the solution of fluid dynamic problems. CFD algorithms will be developed, implemented, analyzed and benchmarked on several different architecture parallel computers.

DTIC
ELECTE
2 1 FEB 1989
S E

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT	21. ABSTRACT SECURITY CLASSIFICATION
UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS ☐	UNCLASSIFIED

22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE NUMBER (Include Area Code)	22c. OFFICE SYMBOL
Dr. LEONIDAS SAKELL	(202) 767 4935	AFOSR/NA

DD FORM 1473, 83 APR EDITION OF 1 JAN 73 IS OBSOLETE.

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFI...

CFD RESEARCH FOR MINI-SUPERCOMPUTERS
A Yale/UTRC Program
Contract # AFOSR-86-0098

Final Report

In the second year of this contract, our research centered on studying various parallel algorithms. This included additional work on the model CFD problem studied in the first year, and work on domain decomposition and fast multipole methods. These latter algorithms show promise for many CFD applications. In particular, the domain decomposition work is already being applied to work in CFD with combustion, and the fast multipole method makes the vortex method for high Reynolds number flow computationally practical.

Greater computational power is needed for solving Computational Fluid Dynamics (CFD) problems of interest in engineering design. Parallel architecture computers offer the promise of providing orders of magnitude greater computational power. We have quantified that promise by considering an explicit CFD method and analyzing the potential parallelism for three different parallel computer architectures. The use of an explicit method gave us a "best case" analysis from the point of view of parallelism, and allowed us to uncover potential problems in exploiting significant parallelism. The analysis was validated against experiments on three representative parallel computers. The results allow us to predict the performance of different parallel architectures. In particular, our results show that distributed memory parallel processors offer greater potential speedup.

The import of our model for the development of parallel CFD and our experiences in converting our model code to run on three different parallel computers was presented as *Computational Fluid Dynamics on Parallel Processors*, AIAA paper 88-3793-CP, at the First National Fluid Dynamics Congress, Cincinnati, OH, July 25-28, 1988.

We considered the application of domain decomposition techniques to the solution of sparse linear systems arising from PDE discretizations on parallel computers. We also considered two representative types of MIMD parallel computer: a message passing and a shared memory architecture. For each we developed complexity estimates and compared these against actual computations. Various

tradeoffs in parallel computation costs were investigated. Our complexity estimates were tested for a variety of methods, decompositions, and problem sizes. This work was described in *Domain Decomposition on Parallel Computers*, presented at the SIAM Conference on Domain Decomposition Methods, January 15-16, 1988.

A Parallel Version of the Fast Multipole Method, (Technical Report YALE/DCS/RR-640, Yale University, Department of Computer Science, August,1988.) presents a parallel version of the Fast Multipole Method (FMM). The FMM is a recently developed scheme for the evaluation of the potential and force fields in systems of particles whose interactions are Coulombic or gravitational in nature. The sequential method requires $O(N)$ operations to obtain the fields due to N charges at N points, rather than the $O(N^2)$ operations required by the direct calculation. We considered the modifications necessary for implementation of the method on parallel architectures and showed that the expected time requirements grow as *log N* when using N processors. Numerical results are given for a shared memory machine (the Encore Multimax 320).

Accession For		
NTIS GRA&I	🗹	
DTIC TAB	☐	
Unannounced	☐	
Justification		
By		
Distribution/		
Availability Codes		
Dist	Avail and/or Special	
A-1		